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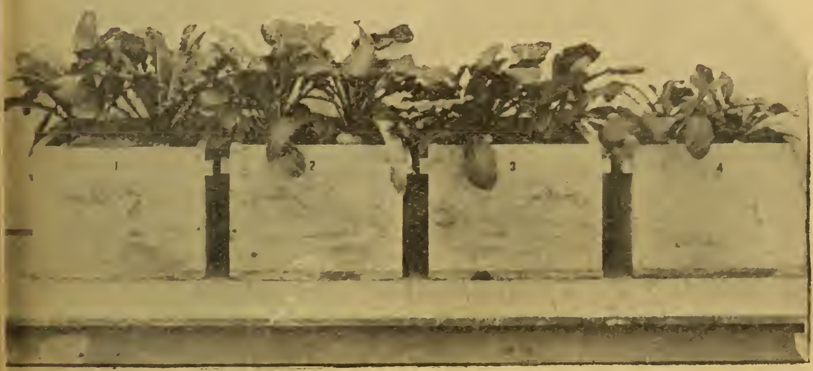
MAINE STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 34. APRIL, 1897.

BOX EXPERIMENTS WITH PHOSPHATES.



TURNIPS.

Box 1. Soluble Phosphoric Acid.
Box 2. Insoluble Phosphoric Acid—Florida Rock.
Box 3. Insoluble Phosphate of Iron and Alumina.
Box 4. No Phosphate added.

Requests for the Bulletins should be addressed to the
AGRICULTURAL EXPERIMENT STATION,
Orono, Maine.

MAINE STATE COLLEGE

AGRICULTURAL EXPERIMENT STATION.

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BOX EXPERIMENTS WITH PHOSPHORIC ACID FROM DIFFERENT SOURCES.

L. H. MERRILL.

Probably nine-tenths of all the commercial fertilizers used in Maine are purchased in the form of "complete" or "mixed fertilizers"—that is, they contain in varying proportions nitrogen, potash and phosphoric acid. While the majority of these goods are honestly made up, yet, like many of the so-called condimental foods, they are designed to cover all probable contingencies and are hence often wastefully applied. It is evident that where but one or two of the constituents named are lacking in a soil, it is not business-like to apply and pay for three. A little intelligent experimenting on the part of the farmer will often determine what is lacking. The next care is to supply this want in the most economical manner.

The use of materials containing nitrogen, phosphoric acid or potash singly is fast growing and is to be encouraged. In the choice of these materials two things are to be considered: the availability, or the readiness with which they can be used by crops, and the cost. It is the object of this bulletin to consider some of the sources of phosphoric acid, with special reference to the matter of availability.

Nearly all of the phosphoric acid used for fertilizing purposes is in combination with lime as phosphate of lime. Three forms are in common use, viz:

1. Insoluble phosphate of lime. This is the form in which nearly all the phosphates exist in nature and from which the other forms described below are derived. The bones of animals are made up largely of this substance and are accordingly extensively used in the preparation of commercial phosphates; but the chief source of the insoluble phosphate now used in this country is rock phosphate, large deposits of which are found in South Carolina and Florida. It is insoluble in water and, unless very finely ground, its phosphoric acid is given up very slowly to the plant.

2. Soluble phosphate of lime. When the insoluble phosphate is treated with dilute sulphuric acid a large part is converted into a form soluble in water, hence known as soluble phosphate. It is then in a condition to be immediately used by the plant. This is the most expensive of the three forms.

3. Reverted or citrate soluble phosphate of lime. If a soluble phosphate is allowed to stand for a long time it frequently happens that much of the soluble phosphate undergoes a change, passing into a form insoluble in water, but much more available to the plant than the original insoluble phosphate from which it was derived. This is the reverted or citrate soluble phosphate. It was formerly supposed to be of much less value than the soluble form, but experience has proved that this is not the case. In fact, if a soluble phosphate is added to a soil, a large part of it reverts before the crops have had time to take it up. It is known as the citrate soluble phosphate because, unlike the insoluble form, it is readily soluble in a hot solution of ammonium citrate. This reagent is therefore employed in the laboratory to distinguish the form in question. The soluble and the citrate soluble are often classed together as available.

There is another phosphate, not so generally used, in which the phosphoric acid is combined with iron and alumina instead of with lime. In its original condition it is not only insoluble in water and but very slightly soluble in hot ammonium citrate, but it is even less available to the plant than the corresponding salt of lime. A phosphate of this description is quarried at Redonda, a small island in the West Indies, and is known as Redonda phosphate or Redondite. It is a characteristic of this phosphate that at a high temperature it loses water, and at the same time becomes largely soluble in ammonium citrate. On long standing a reverse action takes place, the phosphate passing again to the insoluble condition. It is probable that the reversion is more rapid when roasted Redonda has been applied to the soil. Comparatively little of this phosphate is sold, yet on account of the high per centage of phosphoric acid which it carries and the ease with which it may be converted into the citrate soluble condition, it would prove a valuable fertilizer if it is as available to the plant as the chemical analysis would seem to indicate.

A series of experiments has been carried on at this Station to determine the relative value of three forms of phosphatic materials to eight common crops: and also, at the same time, to determine the varying ability of different crops to appropriate phosphoric acid from the same source. The phosphates used were:

1. Acidulated Florida rock. That is, a rock phosphate that had been treated with sulphuric acid, a large part of its phosphate being thereby converted into the available form. This sample contained 20.60 per cent. total phosphoric acid, of which 16.90 per cent. was available (14.97 per cent. soluble, 1.93 per cent. citrate soluble.)

2. Crude, finely ground Florida rock (Floats), containing 32.88 per cent. total phosphoric acid, none of which was soluble, with only 2.46 per cent. soluble in ammonium citrate. This was obtained from the commercial ground rock by stirring it with water, allowing the coarse particles to subside and then pouring off the turbid water. The "Floats" were the sediments deposited from these washings.

3. A phosphate of iron and alumina (Redonda), containing 49.58 per cent. phosphoric acid, a large part of which, 42.77 per cent. was soluble in ammonium citrate.

The plants grown were peas, clover, turnips, ruta-bagas, barley, corn, potatoes and tomatoes. The experiments were conducted in the forcing house, wooden boxes being used, each containing 120 lbs of clean sand.

Ninety-six boxes were used, twelve for each kind of plant. In the first box the acid rock was used; in the second, the crude rock; in the third, the phosphate of iron and alumina; in the fourth, no phosphate. The next four boxes were treated in the same manner, and so on to the end. Thus it will be seen that for each kind of plant there were three boxes which received the same treatment.

Such quantities of the phosphates were used that each box to which they were applied received the same total amount of phosphoric acid. To each box were also added all the ingredients that a healthy plant takes from the soil. These, together with the phosphates, were carefully mixed with the sand before it was placed in the boxes. All the conditions were made as uniform as possible in order that whatever differences were observable might fairly be attributed to the differences in the phosphates used.

When the plants were harvested they were carefully dried, weighed, and the total amount of dry matter determined for each kind of plant grown. The experiments were continued through three periods, the third period being made much shorter than the others.

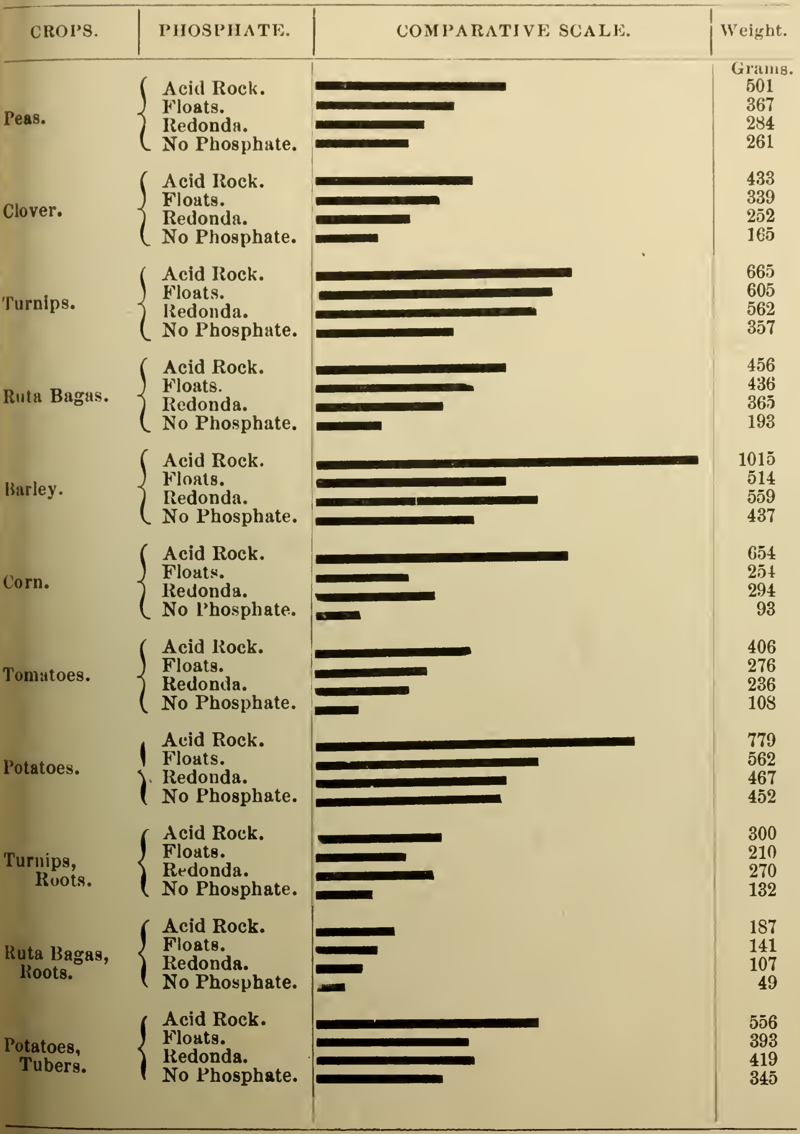
In the diagram on the opposite page, the length of the black lines shows the relative amounts of dry matter produced, while the figures at the right show the actual weights, expressed in grams.

In these experiments the effect of the acid rock was very marked with all the plants grown; those receiving it, in nearly all cases, at once taking the lead and keeping it to the end. The plants were darker green in color, and the tubercles, which were developed on the roots of nearly all the leguminous plants, were larger and much more numerous. It was noticeable, however, that in some cases, especially with the clover, turnips and rutabagas, the good effects of the acid rock were more marked during the first few weeks of growth than at a later stage, when the roots had become more fully developed and had begun to forage for themselves. It would appear that the young plants feed but little upon the insoluble phosphates; but that the organic acids present in the sap of the roots exert a solvent action upon the insoluble phosphates in the soil, gradually converting them into available forms.

It will be noticed that in this work only the immediate effect of the phosphates has been taken into consideration, no mention having been made of the unused phosphoric acid remaining in the soil at the close of the experiment. In actual field work the good effect of the ground rock would, of course, be far more lasting than that of the acid rock.

Box experiments were made at the New Hampshire Experiment Station in 1893 with winter rye, the phosphoric acid being supplied by roasted Redonda, ground bone, and basic slag. The result showed that the rye gave nearly as good returns with the roasted Redonda as with the other phosphates. This result confirms the work here reported. It will be seen by reference to the diagram here given that the corn and barley (plants closely related to rye) gave better results with the Redonda phosphate than with the finely ground Florida rock.

Diagram showing relative weights of dry matter of plants grown with phosphoric acid from different sources.



CROPS.	PHOSPHATE.	COMPARATIVE SCALE.	Weight.
			Grams.
Peas.	Acid Rock.		501
	Floats.		367
	Redonda.		284
	No Phosphate.		261
Clover.	Acid Rock.		433
	Floats.		339
	Redonda.		252
	No Phosphate.		165
Turnips.	Acid Rock.		665
	Floats.		605
	Redonda.		562
	No Phosphate.		357
Ruta Bagas.	Acid Rock.		456
	Floats.		436
	Redonda.		365
	No Phosphate.		193
Barley.	Acid Rock.		1015
	Floats.		514
	Redonda.		559
	No Phosphate.		437
Corn.	Acid Rock.		654
	Floats.		254
	Redonda.		294
	No Phosphate.		93
Tomatoes.	Acid Rock.		406
	Floats.		276
	Redonda.		236
	No Phosphate.		108
Potatoes.	Acid Rock.		779
	Floats.		562
	Redonda.		467
	No Phosphate.		452
Turnips, Roots.	Acid Rock.		300
	Floats.		210
	Redonda.		270
	No Phosphate.		132
Ruta Bagas, Roots.	Acid Rock.		187
	Floats.		141
	Redonda.		107
	No Phosphate.		49
Potatoes, Tubers.	Acid Rock.		556
	Floats.		393
	Redonda.		419
	No Phosphate.		345

SUMMARY.

1. Plants differ in their ability to feed upon crude phosphates.

2. Turnips and ruta-bagas gave nearly as good returns with the Florida rock as with the dissolved rock.

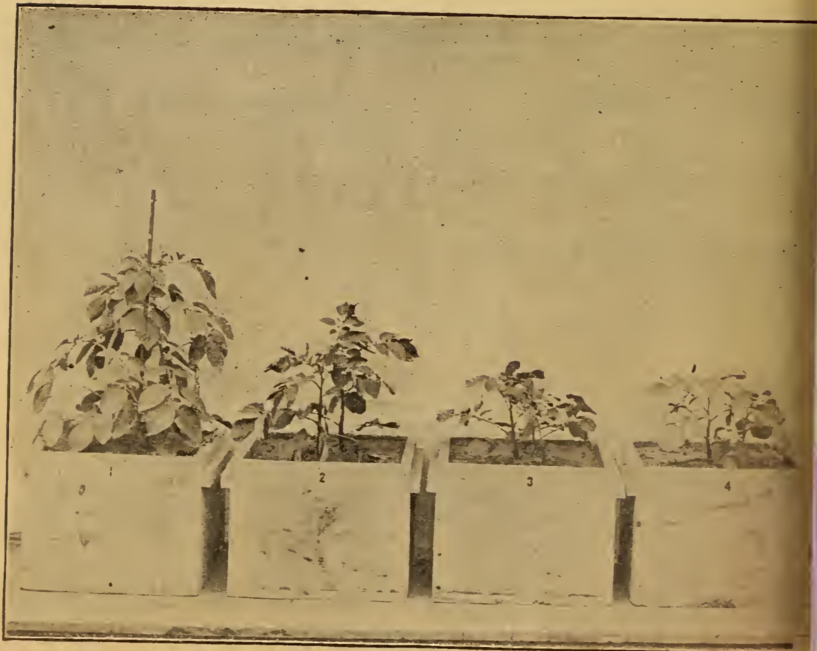
3. In nearly every other case the best results were obtained by the use of the dissolved rock.

4. Barley and corn appear to require an acid phosphate.

5. Except with the barley, corn, turnip roots and potato tubers, the crude Florida rock yielded better returns than the phosphate of iron and alumina.

6. When early maturity is desired, the acid phosphate can profitably be used.

7. The solubility of a phosphate in ammonium citrate is not always the correct measure of its actual value to the plant.



POTATOES.

Box 1. Soluble Phosphoric Acid.
Box 2. Insoluble Phosphoric Acid—Florida Rock.
Box 3. Insoluble Phosphate of Iron and Alumina.
Box 4. No Phosphate added.